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ABSTRACT

Piaget's theory that distinct stages in the organization of memory correspond to successive stages in cognitive development was tested using 150 eighth graders. Cognitive levels were assessed with Inhelder and Piaget's balance beam task, initially, and again at seven months. Mnemonic levels were assessed with Piaget and Inhelder's memory of an arrangement task, both initially and again at six months. The data strongly supported the Piagetian theory linking long-term memory to cognitive development. Immediate recall memory was independent of the initial cognitive assessment, while six-month correct recall, reconstruction, and recognition memory were highly correlated with the seven-month cognitive assessment. Students who were assessed initially as nonformal, but who became formal within the seven-month interval had the same chance of correct recall, reconstruction, and recognition as those initially assessed to be formal. A seven-month formal congitive assessment was generally characteristic of students with correct six-month recall, while the incorrect recognition and incorrect recall/correct recognition groups did not significantly differ with respect to the percent of formal subjects. The results also supported the view that as a child's intelligence develops, changes occur in the way events are remembered. (Author/GDC)

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A Study of the Relationship Between Long-Term Memory and Formal Cognitive Development for Eighth-Grade Students: A Confirmation of Piagetian Theory

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Abstract

The study was designed to test the Piagetian theory that distinct stages in the organization of memory correspond to successive stages in cognitive development. The population consisted of 150 eighth grade students and the study employed a within subject design with all the subjects between the ages of 12 and 14.

Cognitive levels were assessed with a balance beam task from Inhelder and Piaget initially and again at seven months. Mnemonic levels were assessed with Piaget and Inhelder's memory of an arrangement task both initially and again at six months. All assessments were conducted clinically with the use of protocols developed for administering both cognitive and mnemonic tasks.

The data strongly support the Piagetian theory which links long-term memory to cognitive development. Immediate recall memory was found to be independent of the initial cognitive assessment, while six-month correct recall, reconstruction, and recognition memory were found to be highly correlated with the seven-month cognitive assessment. Students assessed initially as nonformal but became formal within the seven-month interval, had the same chance of correct recall, reconstruction, and recognition as those initially assessed to be formal. A seven-month formal cognitive assessment was generally characteristic of students with correct six-month recall, while the incorrect recognition and incorrect recall/correct recognition groups did not significantly differ with respect to the percent of subjects assessed to be formal.

The importance of memory in learning, in the performance of day-to-day responsibilities, in social relationships and the like has made it a focus of interest to psychologists and educators from earliest days. The classical view of memory held it to be associative. Postulating the existence of a "memory trace," its strength was deemed to be dependent on the ability of the holder to associate a given perception or thought with a particular environment. Its strength derived also from repetitions and reinforcement. Its weakness or decline (forgetting) was attributed to disuse and interference.

Because they believed that an understanding of perception would throw light on general principles of brain functioning, Gestalt psychologists studied perception and in the process, particularly the memory of perceptions. They agreed that the incoming sense event, while an important one, was not the only determinant of the perception since the sense event appeared to undergo modification by processes in the central nervous system. In doing so, they included perceptual factors in the bases of mnemonic transformations. (Riley, 1964).

Yet the associative view of memory, while accounting for some mnemonic transformation, was unable adequately to explain memory improvement over time. Memory improvement was attributed to the improvement of the retrieval state and the improved accessibility of the memory trace. Unfortunately neither of these changes was specifically described.

The formulation of a theoretical position that accounted for mnemonic transformations became the achievement of Piaget and Inhelder (1973) who developed an operative theory of memory. By their view, knowledge begins with the assimilation of experience, the hypothetico-mathematical processing of that information, and emerges finally in a set of operational schemata

appropriately responsive to the occurrence of that class or category of experience in the future. Memory is, in part, the availability of the operational schemata when needed. These processes being developmental, they differ over time in the form in which experience for assimilation and processing can occur. The organism differs in its capacity to accept experience. At a given developmental stage, for example, the organism can process experience which occurs in concrete form but will be unable to deal with experience occurring in abstract form. Thus the stage of cognitive development defines and limits the kinds of experience which can be assimilated, processed, and converted to operational schemata. Knowledge and memory are confined to experience consonant with the cognitive stage of development. Memory is durable when the structure to be remembered requires the achievement of an order of schemata paralleling the cognitive stage of development. Memory, if at all, is of short duration when the structure to be remembered requires schemata of an order not yet achieved by the subject. The duration of memory depends upon the parallel between cognitive and memory stages.

Two implications derive from this view. First, there should be differences in the way subjects across ages remember a stimulus or an event. These differences reflect the subjects' operational level at any given point in time. Second, memory undergoes transformation over time so that with the achievement of the appropriate stage, the quality and duration of memory should be substantially better.

Piaget and Inhelder studied cross-age and longitudinal changes in the memory of certain logical structures in children (1973).

One study involved a seriated array of ten wooden rods which are shown to a group of children from three to eight years of age. After one week,

they were asked to produce a drawing of the array and again after eight months.

Following the one week drawing, the operational levels of the children were determined by requiring them to construct the series. Piaget and Inhelder found cross-age differences in the drawings which corresponded to cross-age differences in cognitive level. They found a generally adequate correspondence between the subjects' operational level and the organization of memory exhibited by the drawings obtained after one week.

The drawings made after eight months were better reproductions of the model. Piaget and Inhelder attributed this improvement to the memory's having attached itself to a more highly elaborated schema and this schema provided a better reproduction of the original (1973).

Another study involved the memory of an arrangement of three geometric forms, rectangle, circle, and square, taken two at a time. The permutations were displayed on a card shown to each of 32 children aged 4 to almost 13.

Each child was asked for a brief description of the model and an opinion of whether it was "mixed up" or contained "some order." The child was then asked to make a memory-drawing. A second memory-drawing was demanded a week later, followed by a reconstruction using a larger number of figures than were present in the original. The same procedure was adopted six months later.

They found that memory (recall and reconstruction) was reliable in only those subjects who had reached the age level at which corresponding operations emerge.

The operations involved in these arrangements belong to the propositional or hypothetico-deductive level. It was thus natural to expect, according to Piaget and Inhelder, that correct memories should not appear

until the age of 11 to 12. In fact, 7 of the 9 subjects (77%) having reached the age of at least 10-½ after the presentation remembered correctly. Although the others did not, they nevertheless showed sufficient growth to suggest the impact on memory of evolving operational schemata.

A number of studies either testing the Piagetian view of memory or seeking to replicate the studies from which that view was derived have been completed. While the general phenomena in long-term retention found by Piaget and Inhelder have been replicated, differences have been reported. Some studies (Altemeyer et al. 1969; Dahlem, 1969; Furth et al. 1974; Libben, 1974) have confirmed long-term memory improvement but to a somewhat lesser degree than found by Piaget. Significant but low correlations have been found between performance on mnemonic and operational assessment tasks. However, these relationships did not always change in parallel over the long-term retention interval (Liben, 1977). For example, a child's rating in an operational assessment task might be more or less advanced than the corresponding rating on a mnemonic task.

Cross-sectional studies have demonstrated that developmental trends in memory parallel developing operative schemes. Longitudinal studies have offered only qualified support for the Piagetian position.

Problems in methodology may account for the not utterly consistent results. In some studies (Altmeyer et al. 1969; Dahlem, 1969; Furth et al. 1974) operative level was inferred from mnemonic performance, while in others (Liben, 1974, 1975a; Samuels, 1976) separate operational assessment tasks were included.

Another possible source of inconsistent results is that some of the studies used different time intervals than those used by Piaget and

Inhelder and/or the subjects used were from different populations with incompatable developmental levels (Liben, 1977). Replicated studies including children across wide developmental levels offer support to the Piagetian position of the parallelism of memories and operative levels while studies including children within the same age levels offer limited support of the hypothesis.

Learning from the experience of both Piaget and Inhelder and the researchers who tested and replicated their work, this study used a substantially larger sample and employed a within subject design in which all the children were between the ages of 12 and 14. Moreover, it makes no inference whatever according to age as to level of cognitive development but assessed each of the subjects individually to determine their levels of cognition and memory by tasks that required the achievement of the same higher order structure, that is, formal thought, for their successful accomplishment. Hence, this study was designed to test the Piagetian theory that distinct stages in the organization of memory correspond to successive stages in cognitive development.

Methods and Techniques

The experimental population consisted of 150 eighth grade students from a suburban central New Jersey Middle School.

Cognitive levels were initially assessed with a balance team task (Inhelder and Piaget, 1958). The task involved balancing a beam with two weights by taking into account the distance of each from the fulcrum. Thus, an understanding of the proportionality between weight and distance was necessary for success. According to Piaget, the accomplishment of this task requires the achievement of formal thought operations. Subjects'

operational levels were classified as one of four stages or substages paralleling those described by Inhelder and Piaget (1958).

Mnemonic levels of the subjects were clinically assessed initially be measuring memory of an arrangement of three geometric figures, circle, triangle, and square, taken two at a time. This task, too, according to Piaget requires the achievement of the formal stage of operations. Subjects were classified in one of four mnemonic stages and their substages paralleling the four stages of Piaget and Inhelder (1973). Each subject was given a card containing a picture of the geometric figures and asked a series of questions about the arrangement. They were then told to examine the card as long as necessary for a memory drawing would later be requested.

Six months later recall, reconstruction, and recognition tasks were administered and subjects classified again according to mnemonic levels. Similarly, at seven months, cognitive levels were again assessed and classified. It was not practicable to administer the tests for cognitive level at the same time as the tests for long-term memory. Assessments for cognitive level were made no more than one month later and are considered as existent at the time of the memory tasks.

Protocols for administering both cognitive and mnemonic tasks were formulated as were methods for classifying the responses. The protocols were field-tested and modified in the light of that experience.

Two or three experienced interviewers observed a clinician testing a subject. Interviewers and clinician noted the subject's performance independently and assessments were compared. A tester was classified "validated" when there was consensus among raters. Only clinicians satisfying this requirement were used in the study. All interviews

were recorded on tape for comparison with the written protocol, if needed. All forms and tapes were reviewed by a committee of researchers. In instances of disagreement, the forms and tape were reviewed by two clinicians. Final rating was reached by a consensus of a research review committee.

Inter-rater reliability was .96 on the balance beam task. For immediate recall memory, it was .98 and at seven months, .95. For reconstruction, inter-rater reliability was .98. The recognition task involved a choice by the subject of one drawing from among four, only one of which was correct. No errors were found in the scoring of this task.

Data Analysis

The question being studied is the relationship between cognitive and mnemonic levels of development. Subjects were classified by cognitive levels of operation according to performance on a logical task. Given these classifications, the subjects' performance on mnemonic tasks provided the basis for identifying the relationship between cognitive and mnemonic levels.

Although the study did identify and assemble data by all cognitive and mnemonic stages and substages, these data were collapsed into two cognitive levels, formal (F) and nonformal (N) and two memory levels, correct (C) and incorrect (I). All nonformal cognitive stages (IIA-IIB) were grouped in one category and all formal (IIIA-IIIB) in another in order to center on the difference in responses between formal and nonformal subjects. No level I stages were observed.

In several ways, Piaget identifies the cognitive stage at which formal operations emerge as Stage IIIA:

"The notion of proportions does not appear until formal sub-stage III-A" (Inhelder and Piaget, 164).

"From the point of its appearance during sub-stage IIIB and often even IIIA, formal thinking makes its presence known..." (Inhelder and Piaget, 308).

"Thus it looks as if the combinatorial operations constitute an operational schema that is quite general beginning with a particular stage in development (IIIA)... This scheme is formal, not concrete." (Inhelder and Piaget, 313).

Both "correct" (C) memory stages (IVA and IVB) were grouped in one category and the several "incorrect" (I) memory stages (I-IIIC) were grouped in another so that the appropriate mnemonic and cognitive stages would correspond.

Of the four stages of mnemonic development described by Piaget, he calls stage IV memory "correct" in the sense that it "is reliable in only those subjects who have reached the age at which corresponding operations emerge" (Piaget and Inhelder, 194). Also,

"...correct memory does not appear until the level of propositional or formal operations is reached" (Piaget and Inhelder, 192).

..."the operations...belong to the propositional and hypothetico-deductive levels so that it is only natural that correct memories should not appear until the age of about eleven to twelve" (Piaget and Inhelder, 195).

Piaget has indicated that formal operations emerge at about 11 to 12 years of age. Thus, mnemonic stages IVA and IVB correspond in the study to the cognitive level of formal operations (IIIA and IIIB).

A major concern of the study was the difference between subjects' responses to mnemonic tasks by those at the nonformal (N) and formal (F) level of operations including those whose cognitive level was unchanged (NN and FF) and those who moved into the formal level (NF) in the course of the study.

Separately, for each of the three memory tasks, the cognitive levels and six-month memory assessments of the 150 eighth grade students were cross-classified to form a two-way contingency table with three levels of the joint initial and seven-month cognitive assessments (NN, NF, and FF) and two levels of six-month memory (C and I) assessments. It should be noted that a classification table based upon more than three cognitive levels or more than two memory levels would have resulted in too few observations per cell to satisfy the assumptions for a chi-square correlation analysis. An examination of the cell frequencies of the expanded classification tables did not suggest any trends other than the ones reported here.

Results

The number of students identified as formal and nonformal on the cognitive task is given in Table 1.

Table 1

Immediate Recall vs. Initial Cognitive Assessment

Balance Beam Initial Assessment	Number of Students	Percent Correct Immediate Recall	Chi-Square Test for Independence
N	119	94.12	0.81 (df=1)
F	31	100.00	

The table shows that 94.12 percent of the students in the nonformal group and 100 percent in the formal group correctly recalled the immediate memory task. A chi-square test for independence supports the hypothesis of no difference in correct immediate recall for the formal and nonformal groups ($\chi^2 = 0.81$, $\underline{df} = 1$).

Table 2 contains 95% confidence intervals for probabilities and odds for correct six-month recall, reconstruction, and recognition memory conditioned on the student's initial and seven-month cognitive assessments. The estimates are based upon maximum likelihood procedures for qualitative data (Haberman, 1978).

Table 2

95% Confidence Intervals For Probabilities and Odds For Correct Long-Term Logical Memory Conditioned on Initial and 7-Month Cognitive Level

Balance Beam				Recall		Reconstruction		Recognition	
Initial	7-Month		Number	Prob.	Odds	Prob.	Odds	Prob.	Odds
N	N	(NN)	80	$.04^{+.07}_{-.03}$	$.05^{+.08}_{-.03}$	$.05^{+.07}_{-.03}$	$.06^{+.09}_{-.04}$	$.50 \pm .11$	$1.0^{+.55}_{-.35}$
N	F	(NF)	39	$.36 \pm .15$	$.57^{+.51}_{-.27}$	$.36 \pm .15$	$.57^{+.51}_{-.27}$	$.79 \pm .13$	$3.70^{+4.2}_{-1.96}$
F	F	(FF)	31	$.39 \pm .17$	$.64^{+.66}_{-.32}$	$.42 \pm .17$	$.73^{+.74}_{-.37}$	$.68 \pm .16$	$2.05^{+2.23}_{-1.07}$

Separate tests of independence of joint initial and seven-month cognitive assessments and six-month recall, reconstruction, and recognition memory resulted in highly significant chi-square values of 26.9, 25.9, and 10.36, respectively, with $\underline{df} = 2$. Thus, these data provide evidence that six-month recall, reconstruction, and recognition memories are highly correlated with the student's cognitive assessment at the .001, .001, and .01 significance levels, respectively.

The confidence intervals for the NF and FF groups overlap, supporting the hypothesis of no difference between these two groups for long-term recall, reconstruction, and recognition memory. These results support the hypothesis that six-month memory is dependent on the seven-month cognitive assessment and that students whose initial and seven-month cognitive assessments indicated cognitive growth from the nonformal to formal stage have the same chance of correct recall, reconstruction as those initially assessed to be formal.

Table 3 gives 95% confidence intervals for probabilities and odds for correct recall, reconstruction, and recognition memory conditioned only on the seven-month cognitive assessment.

Table 3

95% Confidence Intervals For Probabilities and Odds For Correct Long-Term Logical Memory Conditioned on 7-Month Cognitive Level

Balance Beam 7-Month	Number	Recall		Reconstruction		Recognition	
		Prob.	Odds	Prob.	Odds	Prob.	Odds
NN	80	$.04^{+.07}_{-.03}$	$.05^{+.08}_{-.03}$	$.05^{+.07}_{-.03}$	$.06^{+.09}_{-.04}$	$.50 \pm .11$	$1.0^{+.55}_{-.35}$
NF and FF	70	$.37 \pm .11$	$.59^{+.37}_{-.22}$	$.39 \pm .11$	$.63^{+.39}_{-.24}$	$.74 \pm .10$	$2.89^{+1.93}_{-1.22}$
DIFFERENCE (F-NF)		$.33 \pm .12$		$.34 \pm .12$		$.24 \pm .15$	
ODDS RATIO (F/NF)			$13.19^{+29.47}_{-9.11}$		$10.75^{+20.39}_{-7.04}$		$2.84^{+2.80}_{-1.41}$

The estimates show that approximately 5% of the nonformal subjects (NN) and approximately 40% of the formal subjects (NF and FF) were rated correct on the recall and reconstruction memory tasks. Approximately 50% of the nonformal subjects and approximately 75% of the formal subjects were rated correct on the recognition memory task.

Expressed in terms of odds, it is estimated with respect to recall memory that for every 5 successful recalls by nonformal subjects, 100 will be unsuccessful. For every 60 correct recalls by formal subjects, 100 will be unsuccessful.

With respect to reconstruction memory for nonformal subjects, for every 6 successful reconstructions, there must be 100 unsuccessful ones. For formal subjects, the figures are 63 successful for every 100 unsuccessful.

With respect to recognition memory for nonformal subjects, for every 100 successful, there will be 100 unsuccessful and for formal, [illegible] successful for every 100 unsuccessful.

In summary, the odds in favor of correct recall, reconstruction and recognition memories are dependent on the seven-month cognitive assessment. However, these odds conditioned on the seven-month cognitive assessment, are independent of the initial cognitive assessment. In particular, the odds in favor of correct recall memory are 13.2 times greater for the cognitively formal group than for the cognitively nonformal. The odds in favor of reconstruction memory are 10.7 times greater for the formal group than for the nonformal group. For recognition memory, the odds are 2.8 times greater for formal than for nonformal subjects.

For each of the long-term memory classifications, Table 4 contains 95% confidence intervals for the probability and odds that a student has a formal seven-month cognitive assessment.

The table shows that 90% of the correct recall group (CR), 39% of the correct recognition-incorrect recall group (CR-IR) and 33% of the incorrect recognition group (IR) were assessed cognitively as formal. Thus, the students in the

Table 4

95% Confidence Intervals For Probabilities and Odds For Formal Cognitive Level (Seven-Month) Conditioned on the Subject's Long-Term Memory Classification

Long-Term Memory Classification	Number	Probability/Odds of Formal Cognitive Level (Seven-Month Assessment) Prob.	Odds
Correct Recognition	96	$.55 \pm .10$	$1.22^{+.60}_{-.40}$
Correct Recall	29	$.90^{+.10}_{-.11}$	$7.57^{+5.68}_{-3.24}$
Incorrect Recall	67	$.39 \pm .12$	$0.64^{+.40}_{-.25}$
Incorrect Recognition	54	$.33 \pm .13$	$0.51^{+.38}_{-.22}$
	150		

long-term CR group are generally assessed to be formal while the IR and the IR-CR groups do not significantly differ with respect to the percent (33 vs. 39) of the subjects assessed to be formal.

Conclusions

In summary, immediate recall memory is independent of the initial cognitive assessment, while six-month correct recall, reconstruction, and recognition memory are highly correlated with the seven-month cognitive assessment. In addition, students assessed initially as nonformal but became formal within the seven-month interval, have the same chance of correct recall, reconstruction, and recognition as those initially assessed to be formal. A seven-month formal cognitive assessment was generally characteristic of students with correct six-month recall, while the incorrect recognition and incorrect recall-correct recognition groups do not significantly differ with respect to the percent of subjects assessed to be formal. Thus the study strongly supports the Piagetian position as summarized by Gruber (650).

"What is astonishing, however, in the experimental results, is that memory depends more on the intellectual level achieved by the child at the moment of recall after six-months than it does on level of development at the moment of the initial exposure to the material."

Educational Importance

This research contributes to the support of Piaget's theory which links long-term memory to cognitive development and is consistent with the view that as the child's intelligence develops, changes occur in the way events are remembered. Using a within-subject design, support for the hypothesized relationship between cognitive and mnemonic levels was obtained.

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